Parity Violating Single Spin Asymmetry in W Production from Longitudinally Polarized p+p Collisions at 500 GeV

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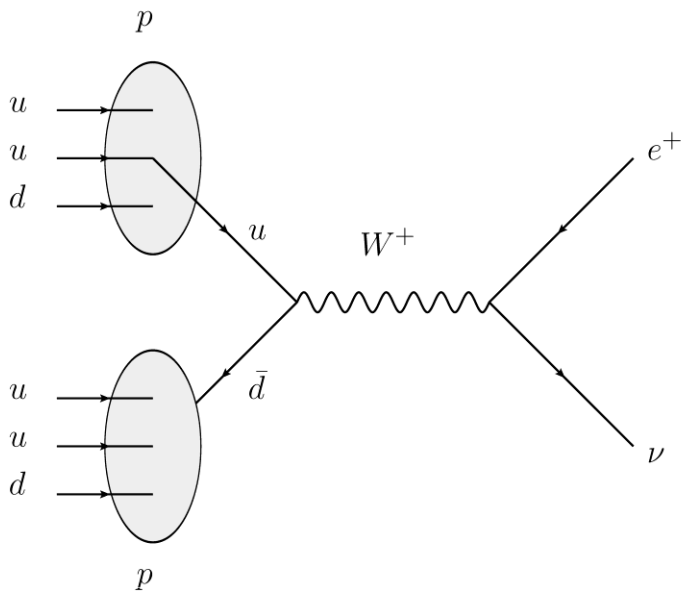
on behalf of the PHENIX Collaboration

$W^{\pm}$ at RHIC

- First look at RHIC and PHENIX performance at √s = 500 GeV in one month run in 2009
- First observation in p+p collisions
- First W's produced with polarized beams
- W's at RHIC used to measure polarized PDF's through measurement of single spin asymmetry

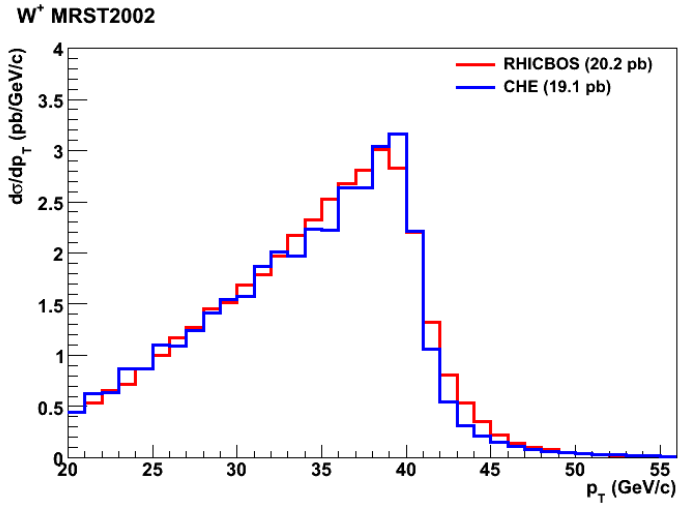
What can W decays at RHIC tell us?

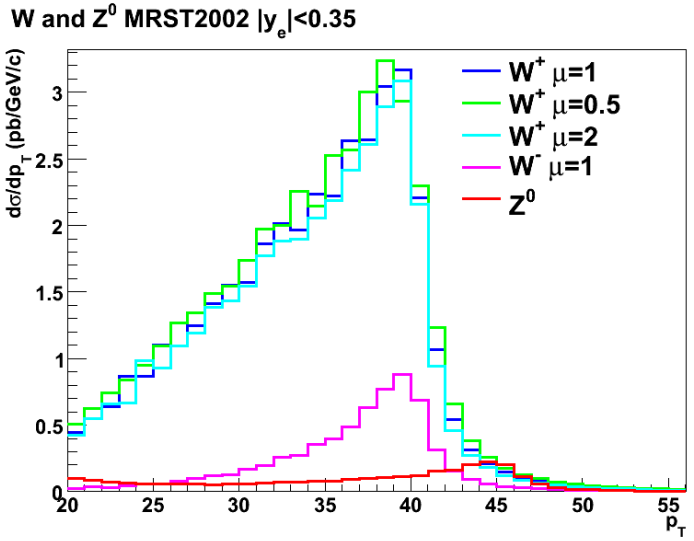
- The $W^{\pm}$ probes the quark distribution in pp
  - Different PDF sampled than in $\bar{p}$+p
- Access to polarized PDF's through
  - Cross section
  - W^+/W^- ratio
  - **Longitudinal spin asymmetry**



Cross section predictions

- LO, NLO, and NNLO calculations
- RHICBOS Monte Carlo includes spin dependent PDF's, soft gluon resummation
- CHE NLO calculation





RHICBOS due to Nadolsky and Yuan, Nucl.Phys.B666:31-55 (2003)

CHE due to de Florian and Vogelsang, arXiv 1003.4533 (2010)

Longitudinal spin asymmetry A_L

Parity violating longitudinal single spin asymmetry defined by

$$\epsilon_L = \frac{N^+ - R \cdot N^-}{N^+ + R \cdot N^-}$$

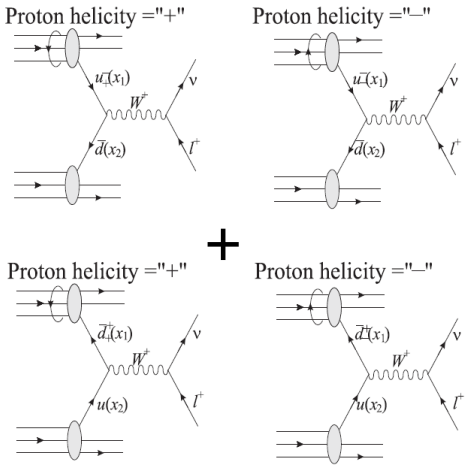
$$A_L = \frac{\epsilon_L \cdot D}{P}$$

- N^+ = right handed production of W
- N^- = left handed production of W
- P = Polarization
- R = relative luminosities of the helicity states
- D = dilution by background and Z^0

Interpreting A_L

$A_L(y)$ probes sea and valence quark PDF's

Example at LO ignoring other quark contributions:

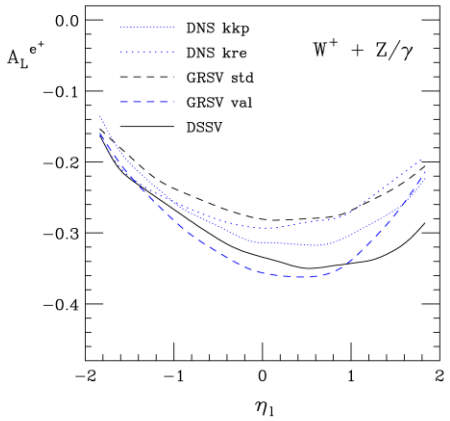


$$= \quad A_L^{W^+} = -\frac{\Delta u(x_1)\bar{d}(x_2) - \Delta\bar{d}(x_1)u(x_2)}{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)}$$

Bunce et al., Ann.Rev.Nucl.Part.Sci.50:525-575,2000 (up to sign convention)

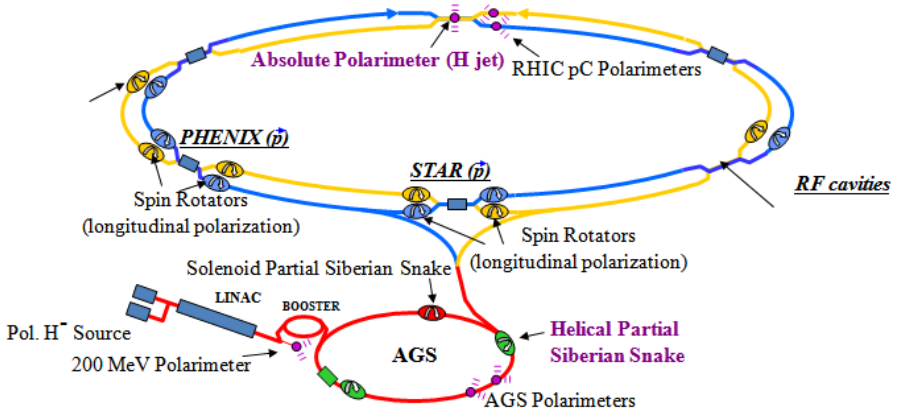
NLO calculations of A_L can be added to PDF fits

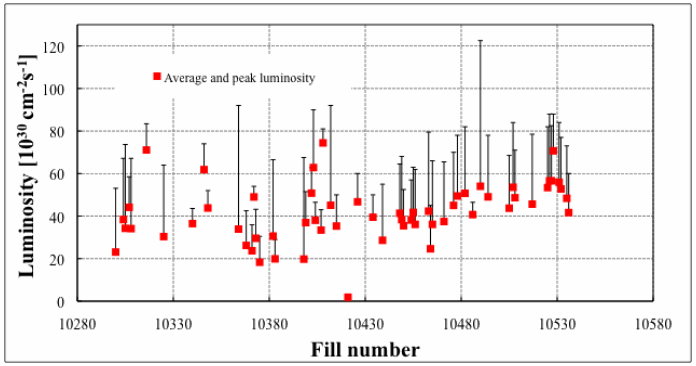
de Florian and Vogelsang, arXiv 1003.4533 (2010



RHIC

- Longitudinally polarized collisions at PHENIX and STAR
- Up to 111 bunch crossings with varied spin orientations for control of systematic errors
- Luminosity typically ≈4x10^{31} cm^{-2}sec^{-1}

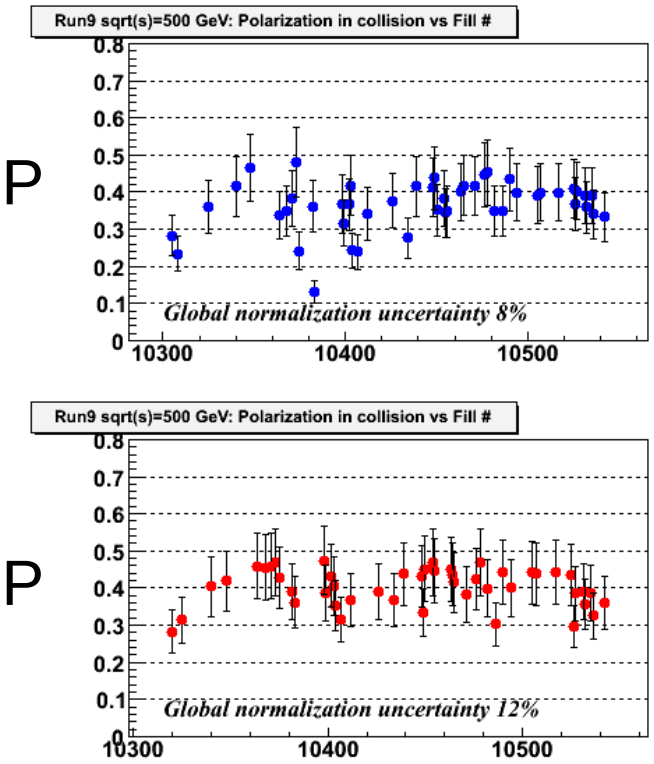




W. Fischer

Polarization

- Measured with two polarimeters
  - CNI polarimeter measurements available during run
  - H jet polarimeter provides absolute polarization
  - Measured residual polarization in real time after rotation at PHENIX

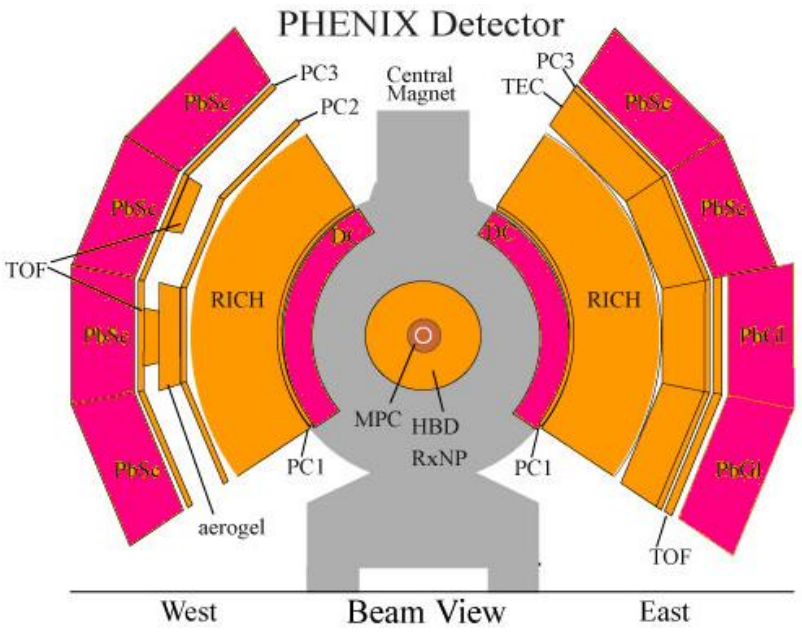


Polarization measured by CNI polarimeters fill-by-fill

PHENIX

Central arm spectrometer

- $|\eta|<0.35$
- EM calorimeter ($\Delta\phi$ x $\Delta\eta \approx 0.01$ x 0.01)
- trigger fully efficient above ≈12 GeV

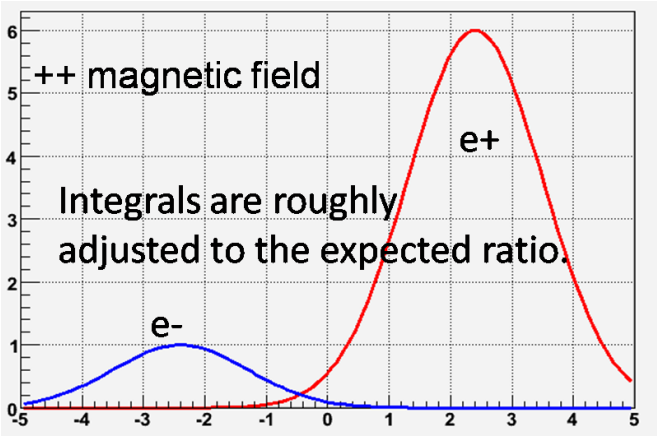


Run 9 500 GeV pp data

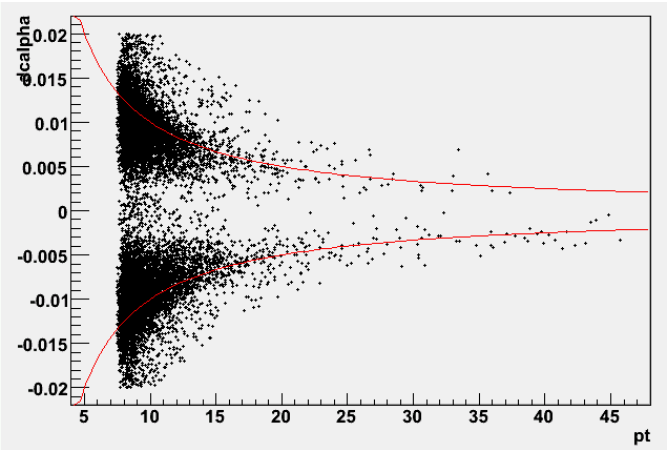
- First 500 GeV in RHIC Run 9: March 17-April 13, 2009
- Machine development in parallel with physics running to increase luminosity, polarization, reduce backgrounds
- Detector challenged by high rates, sometimes high backgrounds
- Forward muon arms running only with prototype trigger electronics, RPC's, and shielding (no forward muon physics reported)

Event selection

- ±30 cm vertex cut
- High energy EM Calorimeter clusters matched to charged track
- Loose timing cut eliminates cosmic rays
- Momentum resolution allows only loose E/p cut
- Charge sign discrimination by measuring bend angle in drift chamber

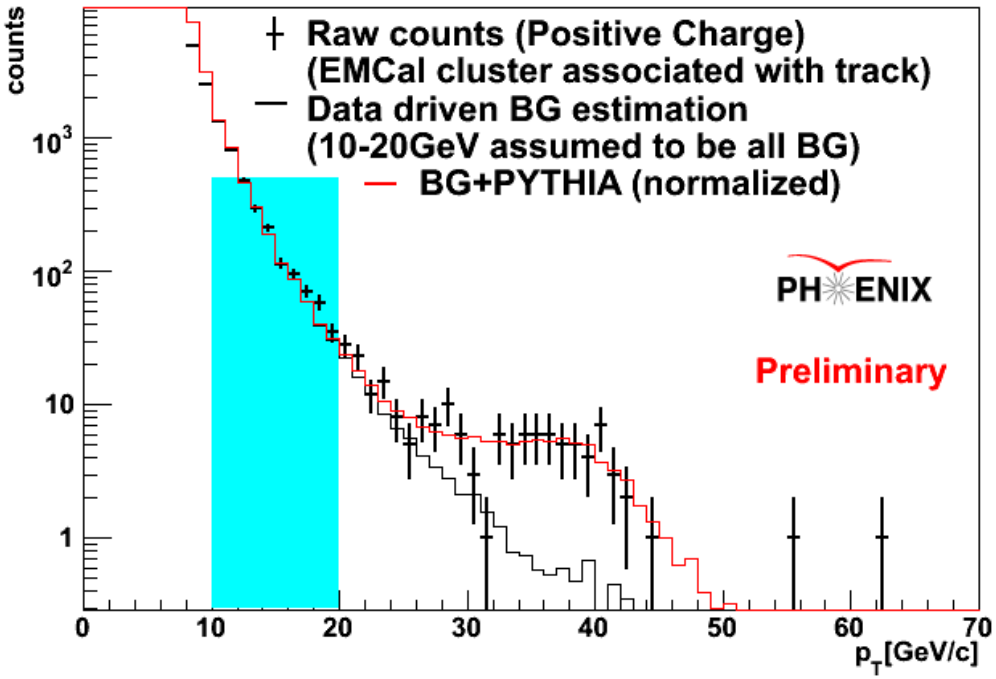


α = bend angle (mr)



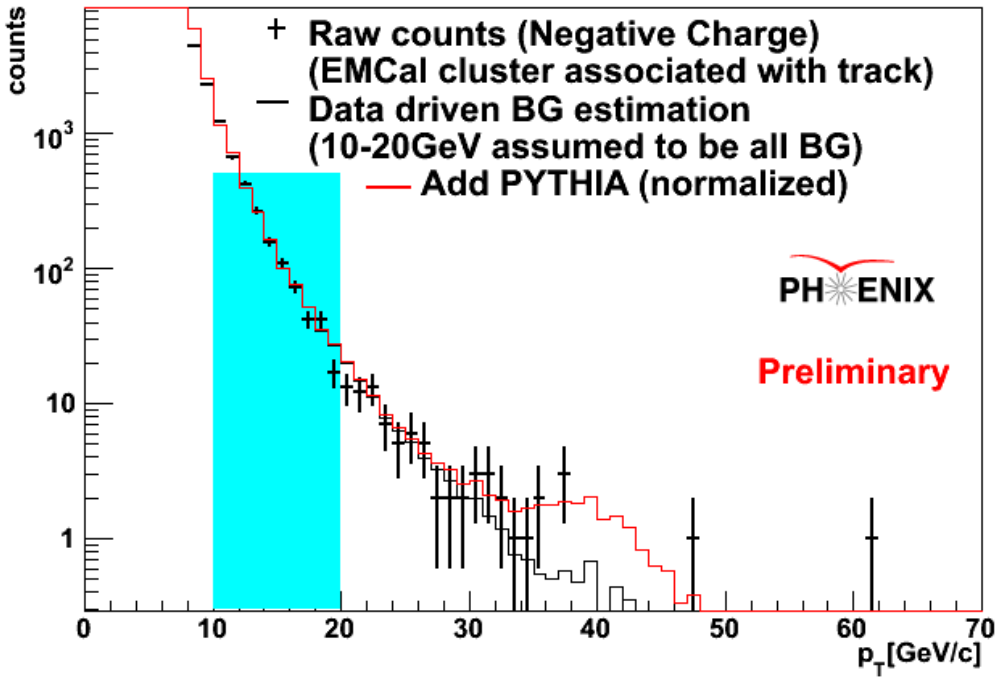
Positive

- Positive charged tracks matched with EM Calorimeter cluster
- Background estimated using 10-20 GeV/c region



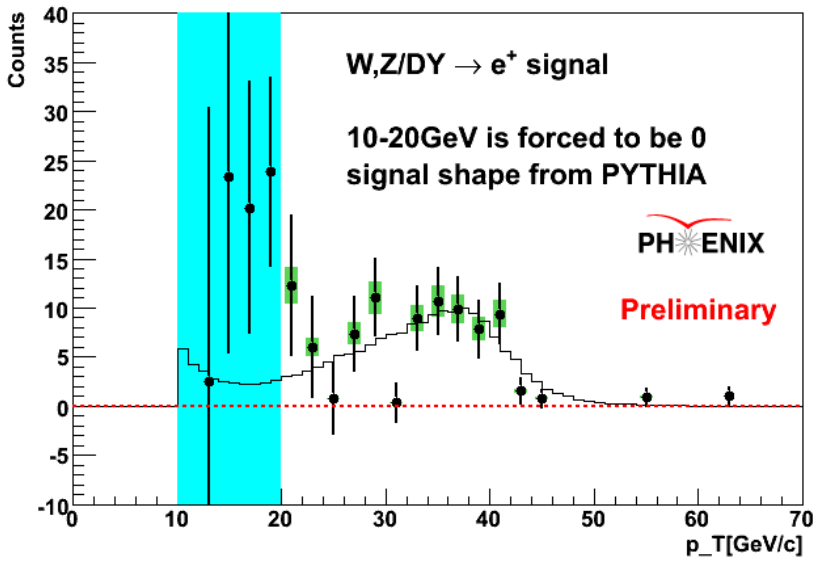
Negative

- Estimated 25% contamination from Z^0 (larger fraction because lower W^- statistics)



Background subtracted

+



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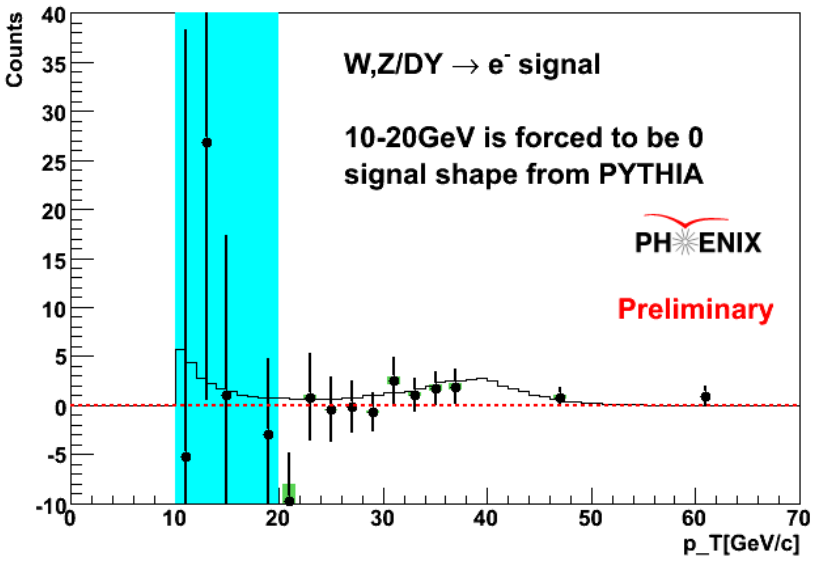
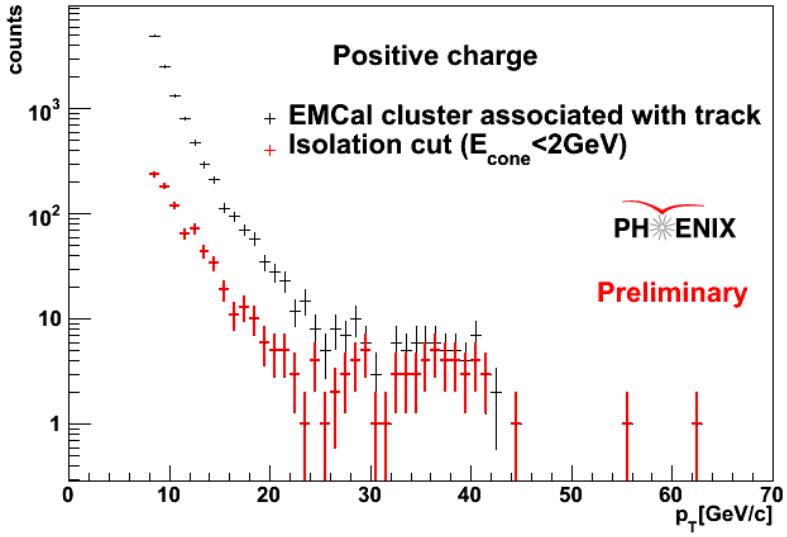
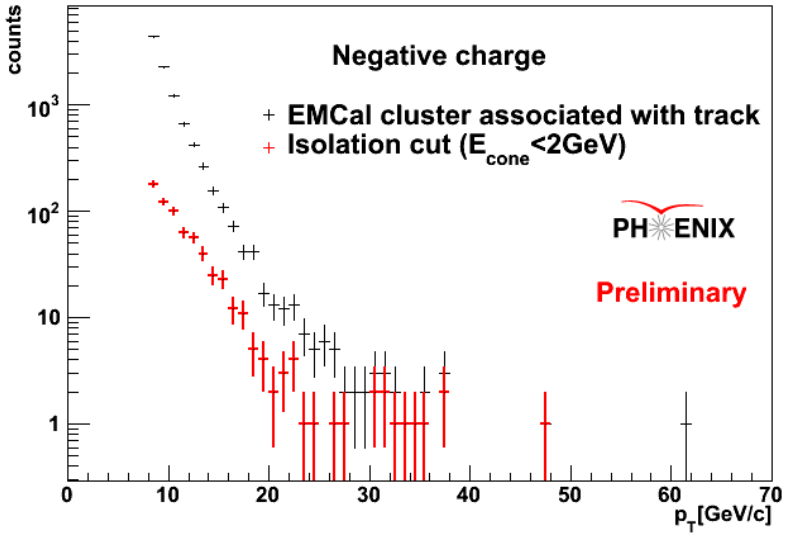


Isolation cut

Lepton side isolation cut used to increase signal/background for asymmetry measurement





Event sample $30<p_T<50$ GeV/c

PHENIX Preliminary from 9.28 pb^{-1} of data

Sample	Raw counts	Background counts	Background subtracted	Isolation cut counts
Positive	60	11.1	48.9	39
Negative	16	10.6	5.4	11
Total	76	21.7	54.3	50

Acceptance

- Acceptance calculation in progress
- Account for acceptance variation during run
- Acceptance factors:
  - Solid angle
  - ±30 cm vertex cut
  - Trigger efficiency
  - Calorimeter hot/dead towers
  - Tracking efficiency
- Cross section agrees within errors of expectation making us confident that we have a understood the signal and backgrounds

A_L measurement

- First measurement with W^+ sample
- Raw asymmetry ε_L measured in background region small and error estimation consistent; by a fitting method, 12-20 GeV, where we expect no asymmetry, we measure:

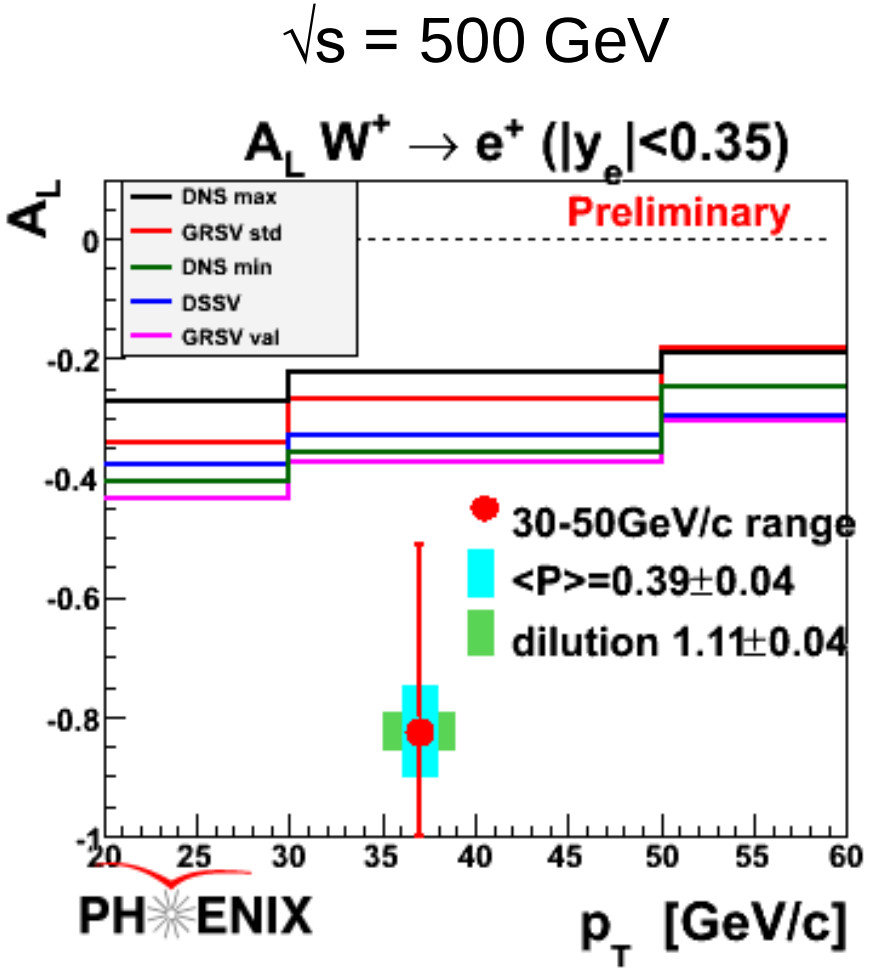
$$\varepsilon_L = +0.035 \pm 0.047$$

A_L for W^+ sample

- Average polarization 0.39±0.04
- Correct polarization for dilution by Z and QCD backgrounds
- Raw asymmetry

-0.29±0.11 leads to

$A_L^{W^+} = -0.83 \pm 0.31$



Conclusion

- PHENIX has seen its first central arm W's
- Acceptance calculation and background estimates in progress
- First attempt to measure single spin asymmetry has detected a parity violating asymmetry leading to a preliminary value of

$$A_L^{W^+} = -0.83 \pm 0.31$$

The future

- In a short exploratory run we have measured A_L in our W^+ sample to be 0.83 ± 0.31
- Future RHIC running at 500 GeV is expected to have higher polarization and longer running time
- The PHENIX detector is undergoing considerable upgrades to enable a program of measurements of $W^{\pm}$ in the forward direction as well